JC10 Rec'd PCT/PTO 07 DEC 2001
10/018454

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DOIEO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

Attorney Docket Number **ItoM 011029**
First Named Inventor **Kasperkovitz**
COMPLETE IF KNOWN
U.S. Application Number
Filing Date

INTERNATIONAL APPLICATION No.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/04993	**29 May 2000**	**8 June 1999**

TITLE: **COMMUNICATION DEVICE**

APPLICANT(S) FOR DO/EO/US: **Kasperkovitz**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(t)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   - b. ☒ has been communicated by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☐ is attached hereto.
   - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   - b. ☒ have been communicated by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(2)),
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 1 54(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☐ Other items or information:

10/018454

531 Rec'd PCT/ 07 DEC 2001

U.S. APPLICATION No. (if known)	INTERNATIONAL APPLICATION No.	ATTORNEY'S DOCKET NUMBER
	PCT/EP00/04993	**ITOM 011029**

21. ☒ The following fees are submitted:

CALCULATIONS (PTO USE)

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1 .445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1040

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ... $890

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $740

International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(l)-(4) $710

International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(l)-(4) $100

ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 890	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	41 - 20 =	21	18	$ 378	
Independent claims	1 - 3 =	0	84	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $280	0	
TOTAL OF ABOVE CALCULATIONS =				658	
☒ Applicant claims small entity status. The fees indicated above are reduced by 1/2.					
SUBTOTAL =				$ 329	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(t)).					
TOTAL NATIONAL FEE =				$ 329	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property				$ 40	
TOTAL FEES ENCLOSED =				$ 369	
				Amount to be refunded:	
				charged:	$ 369

a. ☐ A check in the amount of $ ________ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ______________ in the amount of $ ____________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-0634. A duplicate copy of this sheet is enclosed.

d. ☒ Fees are to be charged to a Credit Card. Form PTO-2038 is attached.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

10/018454
531 Rec'd PCT/PTO 07 DEC 2001

22. SEND ALL CORRESPONDENCE TO:

Robert M. McDermott, ESQ.
52 James Court
Montross, VA 22520
804-493-0707 530-420-4350 (fax)
Patents@Lawyer.com

Customer # **23662**

23662
PATENT & TRADEMARK OFFICE

23. I hereby certify that this paper and the items identified above are being deposited with the U.S. Postal Service "Express Mail Post Office to Addresses" service under 37 C.F.R. Section 1.10 on the 'Date of Deposit', herein indicated, and is addressed to: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

Express mail # EL 921839917 US
Date of Deposit 7 December 2001

Robert M. McDermott
Registration Number 41,508

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of **Kasperkovitz**
Serial No.:
Filed:
Title: **COMMUNICATION DEVICE**

Atty. Docket No.: **ItoM 011029**
Group Art Unit:
Examiner:

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

Preliminary Amendment

Sir:

Prior to calculating the filing fee and examination, please amend the above-identified application as follows.

Please CANCEL all claims, and ADD the following.

11. (Amended) A communication device comprising:

a transmitter,

a receiver,

the transmitter and receiver being coupled to an antenna respectively via a transmitter output and a receiver input, and

a signal corrector that is configured to reduce a transmitter leakage signal at the receiver input,

characterized in that

the signal corrector comprises

a transmitter leakage signal amplifier that is configured to selectively amplify the transmitter leakage signal, wherein

a transmitter signal reference input of the amplifier is coupled to the transmitter output,

a transmitter leakage signal input of the amplifier is coupled to the receiver input, and

a transmitter leakage signal output of the amplifier is coupled to the transmitter leakage signal input to provide a negative feedback of the transmitter leakage signal occurring at the receiver input.

12. (Amended) The communication device according to claim 11, characterized in that the transmitter leakage signal amplifier comprises:

a phase splitter,

a first demodulator and a second demodulator,

a first low pass filter and a second low pass filter

a first modulator and a second modulator, and

a phase inverter,

wherein:

an input of the phase splitter is coupled to the transmitter output,

the phase splitter is configured to supply respectively in-phase and quadrature phase components of the transmitter output to reference signal inputs of the first and second demodulators, as well as to carrier signal inputs of the first and second modulators,

the first and second demodulators include:

transmitter leakage signal inputs in common with the transmitter leakage signal input of the signal corrector, and

outputs coupled respectively through the first and second low pass filters to modulating signal inputs of the first and second modulators,

an output of each of the first and second modulators is coupled in common to the receiver input and the transmitter leakage signal inputs of the first and second demodulators to form a feedback path to the receiver input, and

the phase inverter is included in the feedback path to provide the negative feedback of the transmitter leakage signal occurring at the receiver input .

13. (Amended) The communication device according to claim 12, characterized in that the first and second modulators each comprise

at least one transconductance amplifier, having an output that is coupled in common to the receiver input and the transmitter leakage signal inputs of the first and second demodulators.

14. (Amended) The communication device according to claim 13, characterized in that

the transmitter leakage signal amplifier provides a non-linear amplification of the transmitter leakage signal, based on an amplitude of the transmitter leakage signal.

15. (Amended) The communication device according to claim 14, further including

a dead zone controller coupled between the first and second low pass filters and the first and second modulators that is configured to:

suppress amplitude variations of the respective output signals of the first and second lowpass filters within a range between predetermined first and second threshold levels, and

amplify the amplitude variations beyond said range.

16. (Amended) The communication device according to claim 15, wherein

the range is based on a maximum receiver input voltage.

17. (Amended) The communication device according to claim 15, further including

a duplex filter having first and second stages,

the transmitter output being coupled through the first stage to the antenna,

the antenna being coupled through the second stage to the receiver input and to the transmitter signal reference input of the signal corrector.

18. (Amended) The communication device according to claim 17, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

19. (Amended) The communication device according to claim 18, characterized in that

the dead zone controller comprises

a splitter that is configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components, the amplitude varying components thereof being supplied to control inputs of variable transconductor amplifiers included in the first and second modulators, and

the outputs of the first and second modulators are coupled through phase inverting means to the transmitter leakage output of the signal corrector.

20. (Amended) The communication device according to claim 18, characterized in that:

the dead zone controller comprises

first and second in-phase signal splitters and first and second quadrature phase signal splitters that are configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components,

the positive, respectively negative, components are supplied to control inputs of first variable transconductor amplifiers of the first and second modulators, respectively through first and second phase inverters to second variable transconductor amplifiers of the first and second modulators, and

outputs of the first variable transconductor amplifiers and outputs of the second variable transconductor amplifiers are coupled through third and fourth phase inverters to the transmitter leakage output of the signal corrector.

21. The communication device according to claim 15, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

22. The communication device according to claim 21, characterized in that

the dead zone controller comprises

a splitter that is configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components, the amplitude varying components thereof being supplied to control inputs of variable transconductor amplifiers included in the first and second modulators, and

the outputs of the first and second modulators are coupled through phase inverting means to the transmitter leakage output of the signal corrector.

23. The communication device according to claim 21, characterized in that:

the dead zone controller comprises

first and second in-phase signal splitters and first and second quadrature phase signal splitters that are configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components,

the positive, respectively negative, components are supplied to control inputs of first variable transconductor amplifiers of the first and second modulators, respectively through first and second phase inverters to second variable transconductor amplifiers of the first and second modulators, and

outputs of the first variable transconductor amplifiers and outputs of the second variable transconductor amplifiers are coupled through third and fourth phase inverters to the transmitter leakage output of the signal corrector.

24. The communication device according to claim 14, further including

a duplex filter having first and second stages,

the transmitter output being coupled through the first stage to the antenna,

the antenna being coupled through the second stage to the receiver input and to the transmitter signal reference input of the signal corrector.

25. The communication device according to claim 24, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

26. The communication device according to claim 14, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

27. The communication device according to claim 13, further including

a duplex filter having first and second stages,

the transmitter output being coupled through the first stage to the antenna,

the antenna being coupled through the second stage to the receiver input and to the transmitter signal reference input of the signal corrector.

28. The communication device according to claim 27, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

29. The communication device according to claim 13, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

30. The communication device according to claim 12, characterized in that

the transmitter leakage signal amplifier provides a non-linear amplification of the transmitter leakage signal, based on an amplitude of the transmitter leakage signal.

31. The communication device according to claim 30, further including

a dead zone controller coupled between the first and second low pass filters and the first and second modulators that is configured to:

suppress amplitude variations of the respective output signals of the first and second lowpass filters within a range between predetermined first and second threshold levels, and

amplify the amplitude variations beyond said range.

32. The communication device according to claim 31, wherein

the range is based on a maximum receiver input voltage.

33. The communication device according to claim 32, further including

a duplex filter having first and second stages,

the transmitter output being coupled through the first stage to the antenna,

the antenna being coupled through the second stage to the receiver input and to the transmitter signal reference input of the signal corrector.

34. The communication device according to claim 33, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

35. The communication device according to claim 33, characterized in that

the dead zone controller comprises

a splitter that is configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components, the amplitude varying components thereof being supplied to control inputs of variable transconductor amplifiers included in the first and second modulators, and

the outputs of the first and second modulators are coupled through phase inverting means to the transmitter leakage output of the signal corrector.

36. The communication device according to claim 33, characterized in that:

the dead zone controller comprises

first and second in-phase signal splitters and first and second quadrature phase signal splitters that are configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components,

the positive, respectively negative, components are supplied to control inputs of first variable transconductor amplifiers of the first and second modulators, respectively through first and second phase inverters to second variable transconductor amplifiers of the first and second modulators, and

outputs of the first variable transconductor amplifiers and outputs of the second variable transconductor amplifiers are coupled through third and fourth phase inverters to the transmitter leakage output of the signal corrector.

37. The communication device according to claim 31, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

38. The communication device according to claim 37, characterized in that

the dead zone controller comprises

a splitter that is configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components, the amplitude varying components thereof being supplied to control inputs of variable transconductor amplifiers included in the first and second modulators, and

the outputs of the first and second modulators are coupled through phase inverting means to the transmitter leakage output of the signal corrector.

39. The communication device according to claim 37, characterized in that:

the dead zone controller comprises

first and second in-phase signal splitters and first and second quadrature phase signal splitters that are configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components,

the positive, respectively negative, components are supplied to control inputs of first variable transconductor amplifiers of the first and second modulators, respectively through first and second phase inverters to second variable transconductor amplifiers of the first and second modulators, and

outputs of the first variable transconductor amplifiers and outputs of the second variable transconductor amplifiers are coupled through third and fourth phase inverters to the transmitter leakage output of the signal corrector.

40. The communication device according to claim 12, further including

a duplex filter having first and second stages,

the transmitter output being coupled through the first stage to the antenna,

the antenna being coupled through the second stage to the receiver input and to the transmitter signal reference input of the signal corrector.

41. The communication device according to claim 40, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

42. The communication device according to claim 12, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

43. The communication device according to claim 11, characterized in that

the transmitter leakage signal amplifier provides a non-linear amplification of the transmitter leakage signal, based on an amplitude of the transmitter leakage signal.

44. The communication device according to claim 43, wherein

the transmitter leakage signal amplifier is configured to:

suppress amplitude variations of the transmitter leakage signal within a range between predetermined first and second threshold levels, and

amplify the amplitude variations beyond said range.

45. The communication device according to claim 44, further including

a duplex filter having first and second stages,

the transmitter output being coupled through the first stage to the antenna,

the antenna being coupled through the second stage to the receiver input and to the transmitter signal reference input of the signal corrector.

46. The communication device according to claim 44, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

47. The communication device according to claim 11, further including

a duplex filter having first and second stages,

the transmitter output being coupled through the first stage to the antenna,

the antenna being coupled through the second stage to the receiver input and to the transmitter signal reference input of the signal corrector.

48. The communication device according to claim 47, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

49. The communication device according to claim 11, further including

an attenuator coupled between the antenna and the transmitter signal reference input of the signal corrector.

50. The communication device according to claim 17, characterized in that

the dead zone controller comprises

a splitter that is configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components, the amplitude varying components thereof being supplied to control inputs of variable transconductor amplifiers included in the first and second modulators, and

the outputs of the first and second modulators are coupled through phase inverting means to the transmitter leakage output of the signal corrector.

51. The communication device according to claim 17, characterized in that:

the dead zone controller comprises

first and second in-phase signal splitters and first and second quadrature phase signal splitters that are configured to split in-phase and quadrature phase components of the transmitter signal reference input into positive and negative in-phase and positive and negative quadrature phase components,

the positive, respectively negative, components are supplied to control inputs of first variable transconductor amplifiers of the first and second modulators, respectively through first and second phase inverters to second variable transconductor amplifiers of the first and second modulators, and

outputs of the first variable transconductor amplifiers and outputs of the second variable transconductor amplifiers are coupled through third and fourth phase inverters to the transmitter leakage output of the signal corrector.

REMARKS

The claims have been amended to remove multiple dependencies, and to conform to U.S. patent practice. Claims 11-20 substantially correspond to non-multiple-dependent versions of claims 1-10 as originally filed in the PCT application, and claims 21-51 are combinations of these claims in varying dependent forms, corresponding to select variants of the originally filed multiple-dependent claims.

Respectfully submitted,

Robert M. McDermott, Esq.
Reg. No. 41,508
804-493-0707

CERTIFICATE OF MAILING
It is hereby certified that this correspondence is being deposited with the United States Postal Service as first-class mail in an envelope addressed to:
COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

On 7 December 2001

By

10/018454
PTO/PCT Rec'd 07 DEC 2001

Appendix A: New Introductory of the Description
New part of the Description of Figure 1

Communication device

The invention relates to a communication device comprising a transmitter and a receiver, coupled to antenna means respectively via a transmitter output and a receiver input, as well as corrective signal means arranged for reducing a transmitter leakage signal at the receiver input and provided with a transmitter signal reference input being coupled to the transmitter output.

Communication devices of such type, also being referred to as transceivers, are known e.g. from US patent nr. 5,444,864. In particular transceivers with single antenna means for transmission and reception require specific filtering between antenna, transmitter output and receiver input to protect the receiver during the transmission phase. The isolation between the transmitter output and the receiver input should be high enough to guarantee that the blocking voltage at the receiver input is not reached even under worst case situations where the output power of the transmitter is set to its maximum level and the reflection coefficient of the antenna reaches its maximum value due to body effects. In the known communication device use is made a.o. of a socalled diplexer interconnecting the antenna means with the receiver input and the transmitter output for the purpose of directing signals received by the antenna means to the receiver input and signals to be transmitted from the transmitter output to the antenna means. To cancel the portion of the transmitter signal arriving at the receiver input, e.g. via leakage through the diplexer or electromagnetic radiation coupling, hereinafter also referred to as transmitter leakage signal, use is made of a socalled signal canceler, functioning as said corrective signal means. The signal canceller is to generate a cancellation signal, which is a substantially gain and phase matched estimate of the transmitter leakage signal measured at the receiver input and which is fed forward to the receiver input signal path via a summer, in which it is subtracted from the leakage transmitter signal.

However, the concept of signal cancellation applied in the known communication device is highly demanding with regard to the accuracy and performance of the circuitry needed. For example, the conformity in phase and amplitude between the cancellation signal on the one

hand and the leakage transmitter signal on the other hand is critical for a proper cancellation. Small mutual deviations strongly degrade the cancellation and may even result in an increase of transmitter leakage signal. Apart therefrom, this known concept require the provision of circuitry, which inevitably cause unwanted side effects to occur, such as the summer, which inherent to its function strongly reduces the overall signal to noise ratio of the communication device.

It is a first object of the invention to overcome the above drawbacks of the conventional communication device and to increase the performance thereof.

A second object of the invention is to improve the sensitivity of the receiver in full duplex mode.

According to the invention a communication device comprising a transmitter and a receiver, coupled to antenna means respectively via a transmitter output and a receiver input, as well as corrective signal means arranged for reducing a transmitter leakage signal at the receiver input and provided with a transmitter signal reference input being coupled to the transmitter output, is therefore characterized in that the corrective signal means comprises transmitter leakage signal selective amplifying means arranged for selectively amplifying said transmitter leakage signal, a transmitter leakage signal input being coupled to the receiver input and a transmitter leakage signal output being coupled to said transmitter leakage signal input thereby forming a negative feed back of the transmitter leakage signal occurring at the receiver input.

The invention is based on the recognition that the phase and gain requirements to obtain an effective reduction of the transmitter leakage signal in a feed back loop are much easier to comply with than those to be complied with by the cancellation signal in a feed forward reduction of the transmitter leakage signal. Where the cancellation signal in the known communication device has to narrowly match the transmitter leakage signal in gain and phase, the gain of the leakage transmitter signal in the feedback loop according to the invention only has to be sufficiently large, whereas its phase only has to be reversed, i.e. shifted over a fixed 180°, to obtain an effective reduction thereof. Furthermore, the

feedback concept allows to dispense with circuitry introducing unwanted side effects such as a summer.

A preferred embodiment of such communication device is characterized in that the transmitter leakage signal selective amplifying means comprise a phase splitter, an input thereof being coupled to the transmitter output, supplying respectively in-phase (I) and quadrature phase (Q) components of a transmitter signal to reference signal inputs of first and second demodulators, as well as to carrier signal inputs of first and second modulators, said first and second demodulators having a transmitter leakage signal input in common with a transmitter leakage signal terminal of the corrective signal means being coupled to the receiver input, and outputs being coupled respectively through first and second low pass filters to modulating signal inputs of said first and second modulators, an output of said modulators being coupled in common to the transmitter leakage signal inputs of said first and second demodulators and phase inverting means being included in the signal path of the transmitter leakage signal selective amplifying means.

By applying this measure, the pair of I and Q transmitter output signalcomponents, are respectively used in the first and second demodulators as a demodulation signal for a synchronous quadrature demodulation of the transmitter leakage signal occurring at the receiver input, resulting in I and Q baseband transmitter leakage signalcomponents. After a baseband selection in said first and second low pass filters, these I and Q baseband transmitter leakage signalcomponents are re-modulated using the I and Q transmitter output signalcomponents as modulation carrier signals. The so obtained re-modulated I and Q transmitter leakage signalcomponents are negatively fed back to the receiver input. The phase inversion needed therefore is provided by said phase inverting means and can be applied anywhere in the loop, i.e. in the baseband or in the RF part of the loop.

For a combination of the re-modulated I and Q transmitter leakage signalcomponents into a single transmitter leakage signal at the receiver input without introducing signal distorsion or noise, preferably the first and second modulators each comprise transconductance amplifying means an output thereof being coupled in common to the receiver input and the transmitter leakage signal inputs of said first and second demodulators.

Another preferred embodiment of a communication device according to the invention is characterized in that the transmitter leakage signal selective amplifying means provides a non-linear, input signal amplitude dependent amplification of the selected transmitter leakage signal. This measure allows to adapt the degree of reduction of the transmitter leakage signal to its degrading effect on the receiver input signal, therewith saving power while maintaining optimum performance.

Preferably, the non-linear amplification is being provided by dead zone control means coupled between the first and second low pass filters on the one hand and the first and second modulators on the other hand providing in-phase and quadrature phase components of a baseband modulation signal having a dead zone for amplitude variations of the respective output signals of the first and second lowpass filters within a range between predetermined first and second threshold levels, the in-phase and quadrature phase components of said baseband modulation signal are varying in amplitude with the respective output signals of the first and second lowpass filters for amplitude variations beyond said range.

Dead zone signal amplification is on itself known, e.g. from US patent number 4,277,695. The use thereof in accordance with the above measure allows to adjust the operative range of the corrective means and to trade off noise against receiver performance degradation.

Preferably, said dead zone is being determined by the maximum allowable receiver input voltage. As a result thereof the operation of the corrective means is switched off for those transmitter leakage signals, which are acceptable and do not lead to performance degradation, hereinafter also referred to as desensitization. In said switched off state, the corrective means is prevented from reducing the signal to noise ratio of the receiver input signal.

Another preferred embodiment of a communication device according to the invention is characterized by a duplex filter having first and second stages, the transmitter output being coupled through said first stage to the antenna means, the antenna means being coupled

through said second stage to the receiver input and to the transmitter signal reference terminal of the corrective signal means.

This measure further improves the performance of the communication device mainly in that a reduction in sideband noise is obtained therewith.

Another improvement in noise performance is achieved by an attenuator coupled between the antenna means and the transmitter leakage signal input of the corrective signal means.

Yet another preferred embodiment of a communication device according to the invention is characterized in that said dead zone control means comprises first and second in-phase signal splitters and first and second quadrature phase signal splitters for splitting said dead zone in-phase and quadrature phase components of the baseband modulation signal into positive and negative in-phase and positive and negative quadrature phase components, said positive, respectively negative, components being supplied to control inputs of first variable transconductor amplifiers of the first and second modulators, respectively through first and second phase inverters to second variable transconductor amplifiers of the first and second modulators, outputs of said first variable transconductor amplifiers and outputs of said second variable transconductor amplifiers through third and second phase inverters being coupled to the transmitter leakage signal terminal of the corrective signal means.

This measure allows to combine the re-modulated positive and negative in-phase and positive and negative quadrature phase RF transmitter leakage signalcomponents into a single feed back transmitter leakage signal, without using a resistive voltage summing circuit, therewith preventing this combination from degrading the signal to noise ratio at the receiver input.

Preferably, variable transconductor amplifiers are used only for the amplitude varying ones of the positive and negative in-phase and positive and negative quadrature components of the dead zone baseband modulation signal. This results in a reduction of circuitry needed for an effective implementation of the communication device.

The above and other object features and advantages of the present invention will be discussed in more detail hereinafter with reference to the disclosure of preferred embodiments and in particular with reference to the appended Figures, that show:

Figure 1 a schematic diagram of a communication device according to the invention;

Figure 2 a blockdiagram of a preferred embodiment of a communication device according to the invention;

Figure 3 a blockdiagram of alternative corrective means for use in the communication device of Figures 1 or 2;

Figure 4 a characteristic diagram of the output control signal of the dead zone means for use in the communication device of Figures 1, 2 or 3;

Figure 5 a vector diagram illustrating the reduction of transmitter leakage in a communication device according to the invention;

Figure 6 a vector diagram illustrating the reduction of transmitter leakage in a communication device according to the invention when using a non-ideal quadrature phasesplitter.

Figure 1 shows a communication device according to the invention comprising a transmitter T and a receiver R, coupled respectively via a transmitter output To and a receiver input Ri to an input and an output of a duplex filter DF, an input/output terminal thereof being coupled via a bidirectional link to antenna means ANT. The communication device also comprise corrective signal means C for reducing a transmitter leakage signal Vl leaking through to and occurring at the receiver input Ri. The corrective signal means C is provided with a transmitter leakage signal terminal Tl being coupled to the receiver input Ri and with a transmitter signal reference input Tri being coupled to the transmitter output To. The corrective signal means C comprise transmitter leakage signal selective amplifying means A having a transmitter leakage signal input Tli coupled to the transmitter leakage signal terminal Tl for supplying thereto the transmitter leakage signal Vl occurring at the receiver input Ri. A transmitter leakage signal output Tlo of the selective amplifying means A is commonly coupled with the transmitter leakage signal input and the transmitter leakage signal terminal Tl, therewith closing a feedback loop. The selective amplifying means A provides for a

Appendix A

AMENDED SHEET

selection, amplification (e.g. with factor α) and phase inversion or 180° phase shift of the transmitter leakage signal Vl, resulting in an output signal, in the given example $-\alpha$Vl, which is fed back to its transmitter leakage signal input effecting the transmitter leakage signal in the loop, i.e. the transmitter leakage signal occurring at the receiver input Ri, to reduce to Vl/(1+α).

For the selection of the transmitter leakage signal Vl, the selective amplifying means A may comprise any type of active frequency controlled filter arrangement using the transmitter output signal at the transmitter signal reference input Tri to lock the resonance frequency thereof to the carrier frequency of the transmitter leakage signal to be selected. The selective amplifying means A may alternatively be based on phase splitting of the transmitter leakage signal Vl into its in-phase (I) and phase quadrature (Q) signalcomponents, followed by mutually separated selection and amplification thereof and subsequent re-combination into a single transmitter leakage signal. This will be further clarified with reference to Figures 2 and 3.

Figure 2 shows a blockdiagram of a preferred embodiment of a communication device according to the invention, in which elements corresponding to those shown in Figure 1 have same references.

The transmitter leakage signal selective amplifying means A comprise a phase splitter 10, an input thereof being coupled to the transmitter signal reference input Tri, for splitting the transmitter output signal into a pair of in-phase (I) and phase quadrature (Q) signalcomponents and for supplying those respectively to reference signal inputs of first and second demodulators 1 and 2, as well as to carrier signal inputs of first and second modulators 7 and 8. Said first and second demodulators 1 and 2 both have an input in common with the transmitter leakage signal input of the transmitter leakage signal selective amplifying means A and the transmitter leakage signal terminal Tl of the corrective signal means C and provide for a synchronous quadrature demodulation of the transmitter leakage signal into a pair of baseband I and Q transmitter leakage signalcomponents. Outputs of the first and second demodulators 1 and 2 are respectively coupled through first and second low pass filters 3 and 4 for a selection of said baseband I and Q transmitter leakage

signalcomponents to first and second dead zone control means 5 and 6 providing for a non-linear amplification of said baseband I and Q transmitter leakage signalcomponents. The so amplified baseband I and Q transmitter leakage signalcomponents are thereafter respectively supplied to first and second modulators 7 and 8 providing a re-modulated pair of I and Q transmitter leakage signalcomponents, which are combined at the transmitter leakage signal output of the selective amplifying means A into one single re-modulated transmitter leakage signal. The circuitry 1, 3, 5, 7 and the circuitry 2, 4, 6, 8 therewith respectively form I and Q signal paths of the transmitter leakage signal selective amplifying means A, in which the I and Q transmitter leakage signalcomponents are being processed mutually separated. The re-modulated transmitter leakage signal is negatively fed back to the input of the transmitter leakage signal selective amplifying means A through a phase inverter 9.

The dead zone control means 5 and 6 provide zero output for any signal supplied to their input having a magnitude smaller than a certain predetermined threshold level, and provide high gain amplification (α) to input signals having a magnitude greater than said threshold level. This means, that for magnitudes of the transmitter leakage signals smaller than said threshold level the corrective means are not operative, this effect also being referred to as desensitization of the corrective means. By choosing said threshold level to correspond to the maximum receiver input voltage, a desensitization in correcting insignificant transmitter leakage signals is obtained, which does not degrade the overall receiver performance, while maintaining an effective reduction of significant transmitter leakage signals. Said desensitization furthermore prevents noise from being introduced in the receiver input signal. This all considerably increase the power efficiency as well as the sensitivity of the receiver when operating in full duplex mode.

The duplex filter DF may be constituted by a Fujitsu D5CG type duplex filter having a transmitter related portion DFT, also referred to as first stage, coupled to a receiver related portion DFR, also referred to as second stage, the common connection between those stages being coupled in common to the antenna means ANT and to an input of an attenuator ATT. An output of the attenuator ATT is coupled to the transmitter signal reference input Tri of the corrective signal means C. The transmitter output signal is

supplied through the transmitter related portion DFT prior to the use thereof signal in the transmitter leakage signal selective amplifying means A as demodulation, respectively modulation signal. This results in a reduction of sideband noise at the receiver input. The attenuator ATT further improves the overall performance of the communication device.

Figure 3 shows a blockdiagram of alternative corrective means for use in the communication device of Figures 1 or 2, in which elements corresponding to those shown in Figure 1 have same references. The first and second modulators 7 and 8 are formed by respectively a pair of positive and negative controllable operational transconductor amplifiers 7' and 7" and a pair of positive and negative controllable operational transconductor amplifiers 8' and 8", signal inputs thereof being respectively coupled to the I and Q outputs of the phase splitter 10 and signal outputs thereof being fed back in common to the input of the transmitter leakage signal selective amplifying means A, i.e. the common input of the demodulators 1 and 2. The baseband I and Q transmitter leakage signalcomponents selected by the low passfilters 3 and 4 and amplified in the dead zone control means 5 and 6 are now being used to vary the gain of the respective operational transconductor amplifiers 7', 7", and 8', 8". Said operational transconductor amplifiers have no provision to deal with change in signal polarity of the gain control signal. To overcome this restriction, the dead zone control means 5 and 6 provide for a splitting of the signals to be processed on the basis of their polarity. This will be clarified with reference to Figure 4. The deadzone control means 5 and 6 are provided with positive and negative output terminals 5+ and 5-, respectively 6+ and 6-, the transfer characteristic of the deadzone control means 5 and 6 from their inputs to their respective positive output terminals 5+ and 6+ being represented by a solid line s and the transfer characteristic of the deadzone control means 5 and 6 from their inputs to their respective negative output terminals 5- and 6- being represented by a dotted line d. For input signal magnitudes smaller than a predetermined threshold value Vth, the signals CPI, respectively CPQ, at the output terminals 5+, 5-, 6+ and 6- have zero value. Positive baseband I and Q transmitter leakage signalcomponents selected by the low passfilters 3 and 4 having an amplitude increasing beyond +Vth will generate an outputsignal CPI/CPQ of the deadzone control means 5 and 6 at their respective positive output terminals 5+ and 6+ following the solid line curve s of Figure 4.

Negative baseband I and Q transmitter leakage signalcomponents selected by the low passfilters 3 and 4 having an amplitude decreasing below -Vth will generate an outputsignal CPI/CPQ of the deadzone control means 5 and 6 at their respective negative output terminals 5- and 6- following the dotted line curve d of Figure 4. The threshold value Vth is preferably chosen to correspond to the maximum receiver input level.
The magnitudes of the output signals of the operational transconductor amplifiers are mutually similarly varying with the gain control signals, whereas their phase is either in-phase or in anti phase with their input signals. By choosing the operational transconductor amplifiers 7' and 8' to vary in anti-phase with their input I transmitter leakage signalcomponent and the operational transconductor amplifiers 7" and 8" to vary in-phase with their input Q transmitter leakage signalcomponent a phase inversion is realised without the need for separate phase inverting means, such as the phase inverter 9 in Figure 2.

Figure 5 shows a vector diagram illustrating the reduction of transmitter leakage in a communication device according to the invention as shown in Figures 2 and 3, in which Vl represents the transmitter leakage signal occurring at the receiver input Ri without the corrective signal means C. The I and Q components of this transmitter leakage signal Vl, i.e. Vli and Vlq respectively, are separately suppressed in the I and Q signal paths to result in a suppressed transmitter leakage signal having a magnitude at most substantially equal to the maximum receiver input level, which is acceptable and does not degrade the performance noticeably.

The phase shift of the transmitter leakage signal Vl occurring in the duplex filter DF will in practise not vary over 360°. This means, that not all four output signals CPI/CPQ of the deadzone control means 5 and 6 at their respective positive and negative I and Q output terminals 5+, 5- and 6+, 6- will vary in magnitude. Dependent from the I/Q phase quadrant(s), the vector representing the transmitter leakage signal Vl occurring at the receiver input never enters, one or two of the operational transconductor amplifiers 7', 7", 8' and 8" can be omitted. For example, if vector Vl only varies over a phase angle within the first I/Q phase quadrant (the projections of Vl on the I and Q axis being positive), than only transconductor amplifiers 7' and 8' are needed and the operational transconductor

amplifiers 7" and 8" can be dispensed with. This simplifies the implementation of the corrective signal means. In general, the phase shift of the duplex filter DF can be measured once and dependent on this phase shift one or more of the transconductor amplifiers 7', 7", 8' and 8" can be omitted.

Figure 6 shows a vector diagram illustrating the reduction of transmitter leakage in a communication device according to the invention when using a non-ideal quadrature phasesplitter 10. Despite of the non-orthogonal I/Q phase splitting, the corrective signal means according to the invention remain to be effective, reducing the I and Q components of the transmitter leakage signal Vl to an acceptable magnitude.

New Claims:

1. Communication device comprising a transmitter (T) and a receiver (R), coupled to antenna means (ANT) respectively via a transmitter output (To) and a receiver input (Ri), as well as corrective signal means (C) arranged for reducing a transmitter leakage signal (Vl) at the receiver input (Ri) and provided with a transmitter signal reference input (Tri) being coupled to the transmitter output (To), characterized in that the corrective signal means (C) comprises transmitter leakage signal selective amplifying means (A) arranged for selectively amplifying said transmitter leakage signal (Vl), a transmitter leakage signal input (Tli) being coupled to the receiver input (Ri) and a transmitter leakage signal output (Tlo) being coupled to said transmitter leakage signal input (Tli) thereby forming a negative feed back of the transmitter leakage signal (Vl) occurring at the receiver input (Ri).

2. Communication device according to claim 1, characterized in that the transmitter leakage signal selective amplifying means (A) comprise a phase splitter (10), an input thereof being coupled to the transmitter output (To), supplying respectively in-phase and quadrature phase components (I, Q) of a transmitter signal to reference signal inputs of first and second demodulators (1, 2), as well as to carrier signal inputs of first and second modulators (7, 8), said first and second demodulators (1, 2) having a transmitter leakage signal input in common with a transmitter leakage signal terminal (Tl) of the corrective signal means (C) being coupled to the receiver input (Ri), and outputs being coupled respectively through first and second low pass filters (3, 4) to modulating signal inputs of said first and second modulators (7, 8), an output of said modulators (7, 8) being coupled in common to the transmitter leakage signal inputs of said first and second demodulators (1, 2) and phase inverting means (9) being included in the signal path of the transmitter leakage signal selective amplifying means (A).

3. Communication device according to claim 2, characterized in that the first and second modulators (7, 8) each comprise transconductance amplifying means (7and

7"; 8'and 8") an output thereof being coupled in common to the receiver input (Ri) and the transmitter leakage signal inputs of said first and second demodulators (1, 2).

4. Communication device according to one of claims 1 to 3, characterized in that the transmitter leakage signal selective amplifying means (A) provides a non-linear, input signal amplitude dependent amplification of the selected transmitter leakage signal (Vl).

5. Communication device according to claim 4, characterized by dead zone control means (5, 6) coupled between the first and second low pass filters (3, 4) on the one hand and the first and second modulators (7, 8) on the other hand providing in-phase and quadrature phase components of a baseband modulation signal having a dead zone for amplitude variations of the respective output signals of the first and second lowpass filters (3, 4) within a range between predetermined first and second threshold levels (+Vth, -Vth), the in-phase and quadrature phase components of said baseband modulation signal varying in amplitude with the respective output signals of the first and second lowpass filters (3, 4) for amplitude variations beyond said range.

6. Communication device according to claim 5, characterized by said dead zone being determined by the maximum receiver input voltage.

7. Communication device according to one of claims 1 to 6, characterized by a duplex filter (DF) having first and second stages (DFT, DFR), the transmitter output (To) being coupled through said first stage (DFT) to the antenna means (ANT), the antenna means (ANT) being coupled through said second stage (DFR) to the receiver input (Ri) and to the transmitter leakage signal terminal (Tl) of the corrective signal means (C).

8. Communication device according to one of claims 1 to 7, characterized by an attenuator (ATT) coupled between the antenna means (ANT) and the transmitter leakage signal terminal (Tl) of the corrective signal means (C).

9. Communication device according to one of claims 5 to 8, characterized in that said dead zone control means (5, 6) comprise means for splitting the in-phase and quadrature phase components of the baseband modulation signal into positive and negative in-phase and positive and negative quadrature phase components, the amplitude varying components thereof being supplied to control inputs of variable transconductor amplifiers (7'and 7"; 8'and 8") included in said first and second modulators (7, 8), outputs thereof being coupled through phase inverting means to the transmitter leakage signal terminal (Tl) of the corrective signal means (C).

10. Communication device according to one of claims 5 to 8, characterized in that said dead zone control means (5, 6) comprise first and second in-phase signal splitters and first and second quadrature phase signal splitters for splitting said dead zone in-phase and quadrature phase components of the baseband modulation into positive and negative in-phase and positive and negative quadrature phase components, said positive, respectively negative, components being supplied to control inputs of first variable transconductor amplifiers (7', 8') of the first and second modulators (7, 8), respectively through first and second phase inverting means to second variable transconductor amplifiers (7", 8") of the first and second modulators (7, 8), outputs of said first variable transconductor amplifiers (7', 8') and outputs of said second variable transconductor amplifiers (7", 8") through third and fourth phase inverting means being coupled to the transmitter leakage signal terminal (Tl) of the corrective signal means (C).

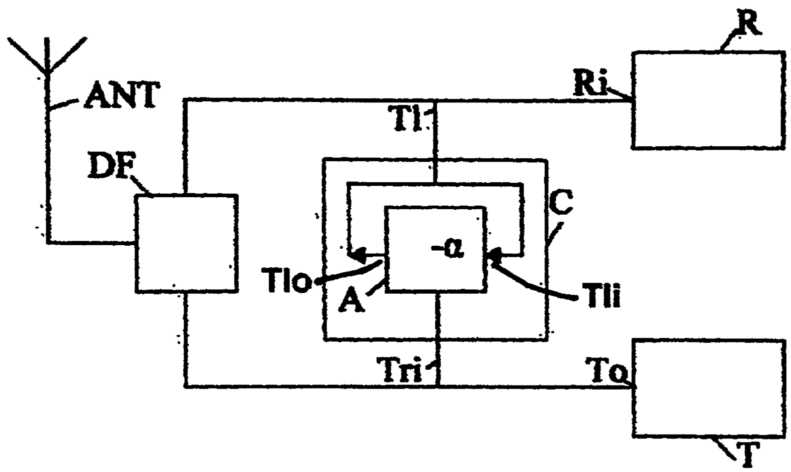

Figure 1

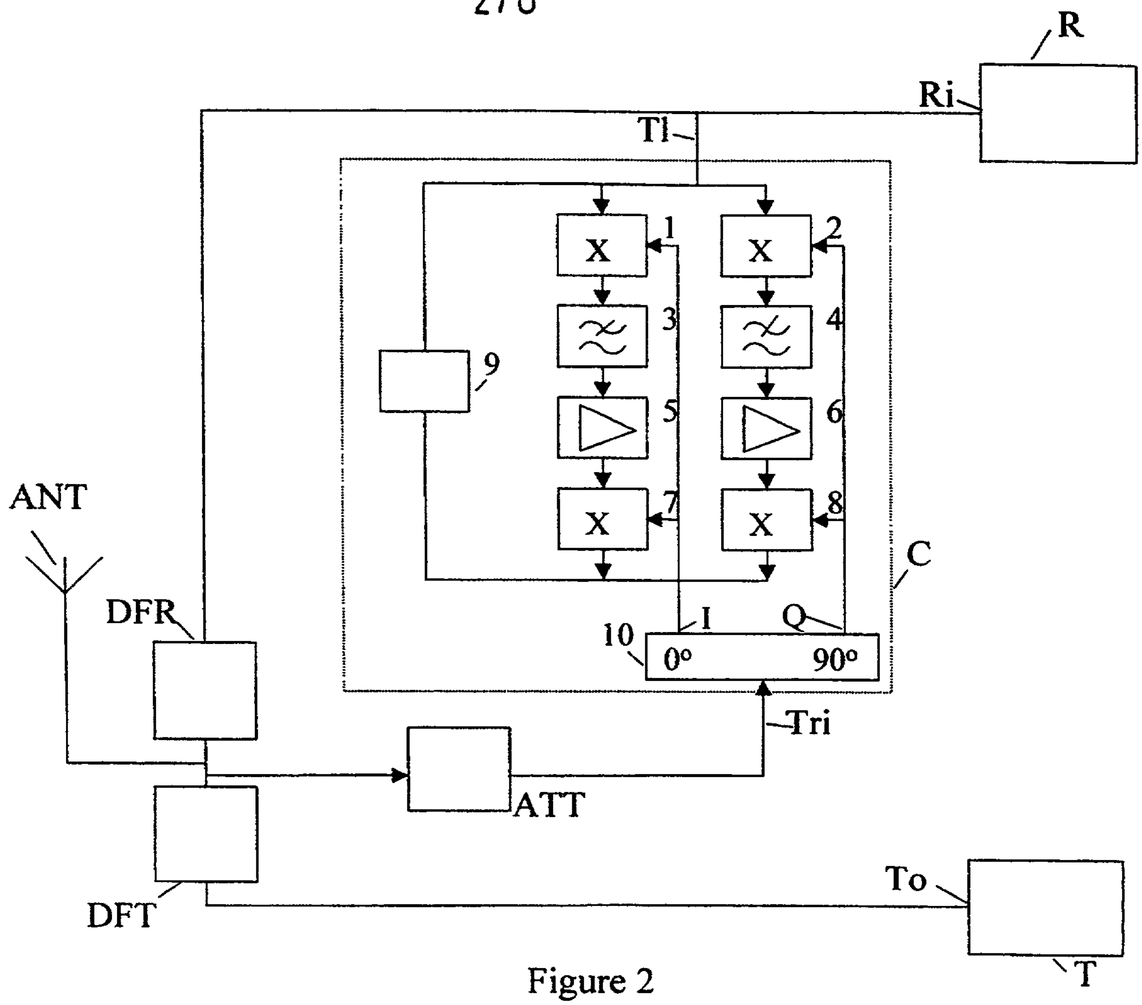

Figure 2

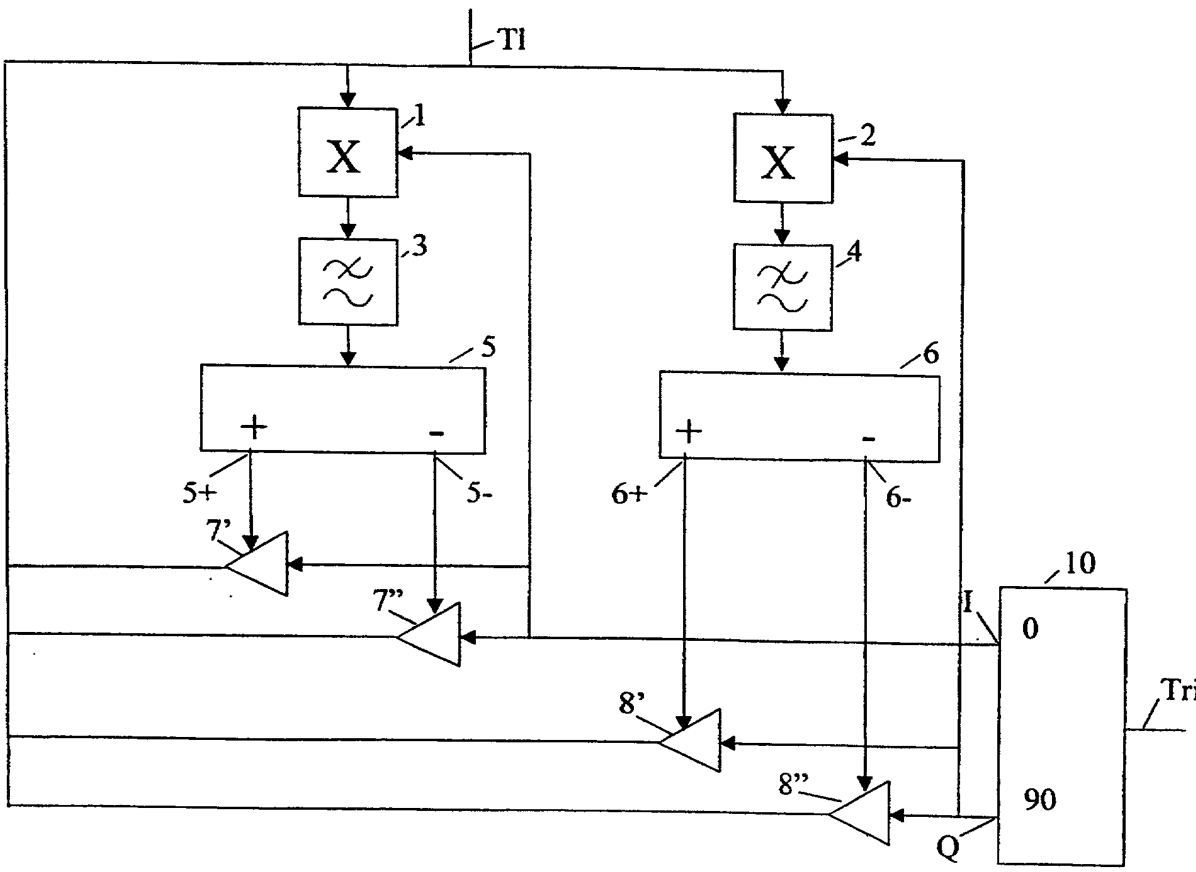

Figure 3

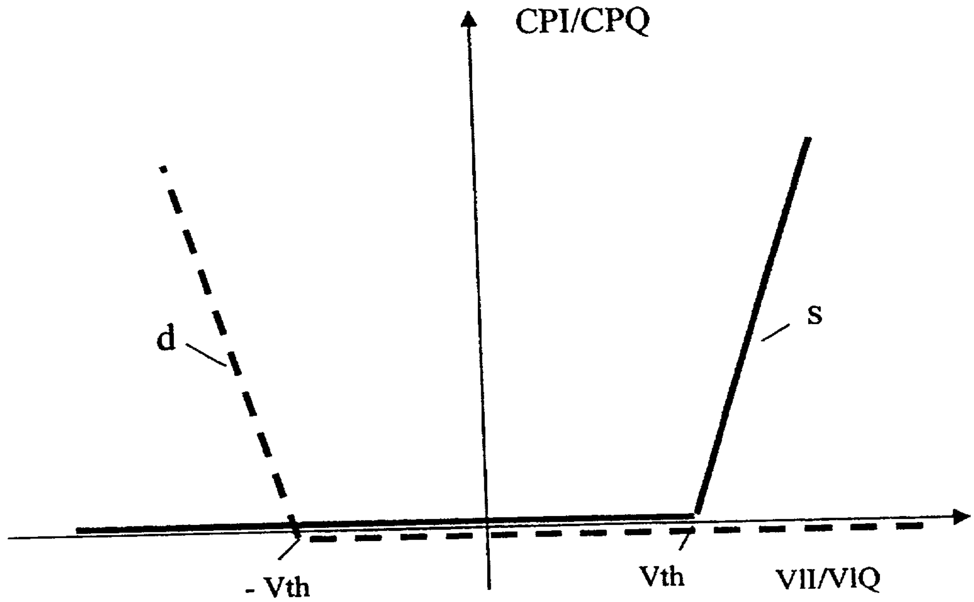

Figure 4

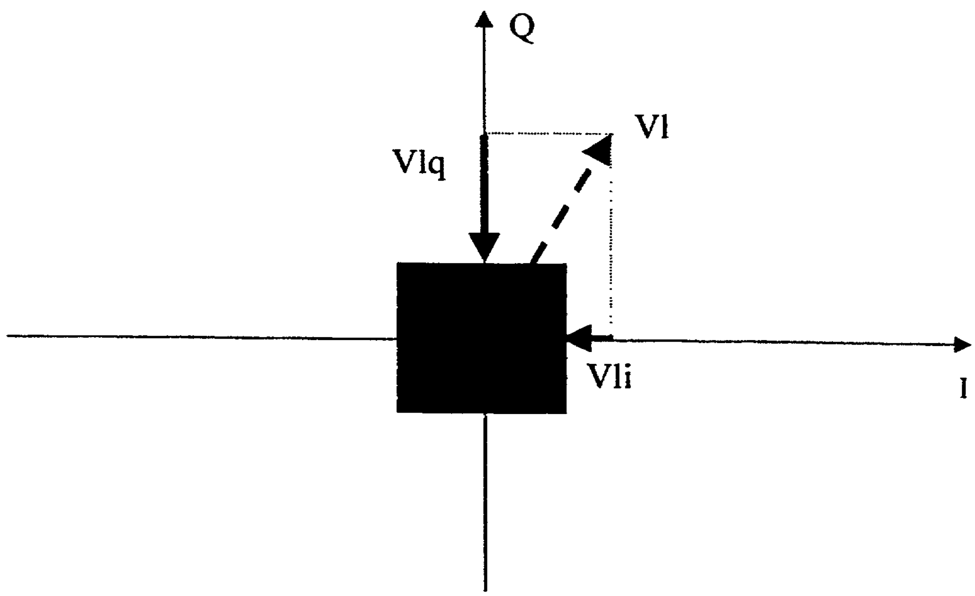

Figure 5

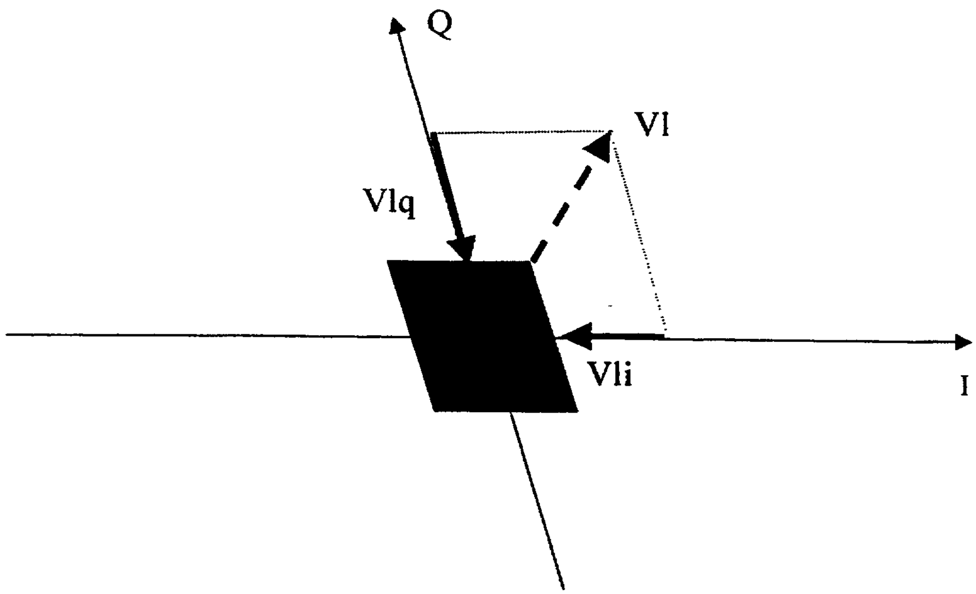

Figure 6

DECLARATION and POWER OF ATTORNEY

Attorney's Docket No. HoM 011029

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter that is claimed and for which a patent is sought on the invention entitled

COMMUNICATION DEVICE,

the specification of which (check one)

_ is attached hereto. X has been communicated by the International Bureau as International Application No. PCT/EP00/04993.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by the amendment(s) referred to above. I acknowledge the duty to disclose information that is material to the patentability of this application in accordance with Title 37, Code of Federal Regulation, Sec. 1.56(a).

I hereby claim foreign priority benefits under 35 U.S.C. 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

COUNTRY	APPLICATION NUMBER	DATE OF FILING (DAY, MONTH, YEAR)	PRIORITY CLAIMED UNDER 35 U.S.C. 119
Europe	EP 99201803.6	8 June 1999	YES

I hereby claim the benefit under 35 U.S.C. 120 of any United States application (s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35 U.S.C. 112, I acknowledge the duty to disclose material information as defined in 37 CFR 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

PRIOR UNITED STATES APPLICATION(S)

APPLICATION SERIAL NUMBER	FILING DATE	STATUS (PATENTED, PENDING, ABANDONED)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number): Robert M. McDermott, Reg. No. 41,508

SEND CORRESPONDENCE TO:	DIRECT TELEPHONE CALLS TO:
Robert M. McDermott, ESQ. Customer ID 23662 52 James Court Montross, VA 22525	Robert M. McDermott 804-493-0707

Dated: 4-12-2001		Inventor's Signature: Wolfdietrich Georg Kasperkovitz		
Full Name of Inventor	Last Name Kasperkovitz	First Name (and Middle, if any) Wolfdietrich Georg		
Residence & Citizenship	City Waalre	State or Foreign Country The Netherlands	Country of Citizenship The Netherlands	
Post Office Address	Street Eikenlaan 4, NL-5581 HA	City Waalre	State or Country The Netherlands	Zip Code

1-00

NLX